ABSTRAK

Perubahan iklim yang memicu cuaca ekstrem dan anomali suhu berdampak buruk pada sektor pertanian, sehingga sistem pemantauan *Internet of Things* (IoT) konvensional yang hanya bersifat reaktif tidak lagi memadai untuk pengambilan keputusan. Penggunaan model prediksi pertanian seperti LSTM juga masih memiliki kelemahan, yaitu rentan terhadap akumulasi error pada *long-term forecasting*. Oleh karena itu, penelitian ini bertujuan mengimplementasikan arsitektur *Patch Time Series Transformer* (PatchTST) untuk memprediksi kondisi lingkungan budidaya selada merah keriting, meliputi suhu, kelembapan, intensitas cahaya, curah hujan, dan cuaca. Penelitian ini menggunakan metodologi CRISP-DM dengan memanfaatkan dataset deret waktu multivariat dari *Open-Meteo Archive API* (2020–2026) serta data aktual sensor IoT. Untuk mengatasi kendala interpretasi data numerik bagi petani, sistem memadukan hasil prediksi PatchTST dengan *Large Language Model* (LLM) Qwen 2.5/14B yang berfungsi menerjemahkan data teknis menjadi rekomendasi tindakan mitigasi berbahasa alami. Hasil pengujian menunjukkan bahwa arsitektur PatchTST mampu melakukan *long-term forecasting* yang stabil hingga horizon 720 jam (30 hari). Kinerja terbaik pada model regresi didapatkan pada prediksi intensitas cahaya dengan nilai *Mean Absolute Error* (MAE) sebesar 0,177 dan *Mean Squared Error* (MSE) 0,099, sedangkan pada pemodelan klasifikasi cuaca mencapai *Mean Accuracy* sebesar 75,45%. Implementasi akhir membuktikan bahwa integrasi PatchTST dengan IoT dan LLM berhasil mewujudkan sistem pendukung keputusan *smart farming* yang tidak hanya akurat secara prediktif, tetapi juga preskriptif dan mudah dipahami oleh pengguna.

Kata kunci: *Smart Farming, PatchTST, Long-term Forecasting, Internet of Things (IoT), Large Language Model (LLM), Time Series.*

ABSTRACT

Climate change, which triggers extreme weather and temperature anomalies, has a severe impact on the agricultural sector, rendering reactive conventional Internet of Things (IoT) monitoring systems inadequate for decision making. The utilization of models like LSTM for agricultural prediction also has significant drawbacks, mainly their vulnerability to error accumulation in long-term forecasting. Therefore, this study aims to implement the Patch Time Series Transformer (PatchTST) architecture to accurately predict the environmental cultivation conditions for curly red lettuce, including temperature, humidity, light intensity, precipitation, and weather. This research employs the CRISP-DM methodology, utilizing multivariate time series datasets from the Open-Meteo Archive API (2020–2026) and realtime IoT sensor data. To overcome the interpretability gap of numerical data for farmers, the system will integrate the PatchTST predictions with a Large Language Model (LLM), Qwen 2.5/14B, to translate technical data into natural language mitigation recommendations. The evaluation results demonstrate that the PatchTST architecture is capable of stable long-term forecasting up to a 720-hour (30 days) horizon. The best performance among the regression models was achieved in predicting light intensity with a Mean Absolute Error (MAE) of 0.177 and a Mean Squared Error (MSE) of 0.099, while the weather classification model reached a Mean Accuracy of 75.45%. The final deployment proves that the integration of PatchTST, IoT, and LLM successfully establishes a smart farming decision support system that is not only predictively accurate but also prescriptive and user-friendly.

Keywords: Smart Farming, PatchTST, Long-Term Forecasting, Internet of Things (IoT), Large Language Model (LLM), Time Series.